HHFW Heating and Current Drive of NBI Heated Plasmas

XP311 Approved

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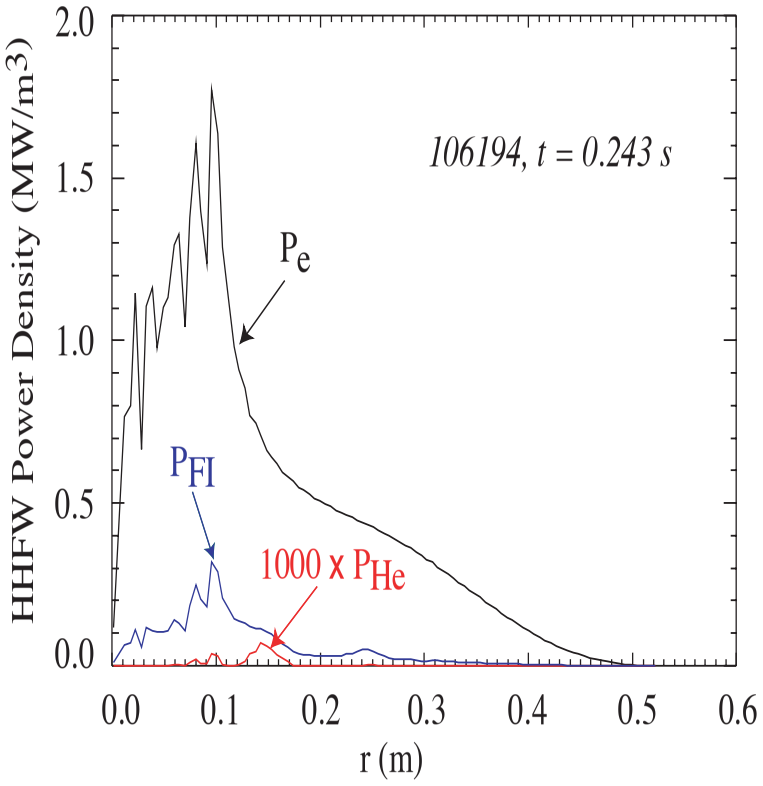
HHFW Heating and Current Drive of NBI Heated Plasmas: Goals

- Show significant heating at highest possible HHFW power
  - Target k// = 7 m^{-1}, with co-, iso-, counter- phasing.
  - Investigate:
    - Loading versus phasing
    - Electron and ion heating versus phasing
    - Energetic ion production
    - MHD activity
- Provide suitable HHFW+NBI plasmas for NSTX research
- Ascertain HHFW-CD in HHFW+NBI plasmas

HHFW at High Beta Heats Off Axis

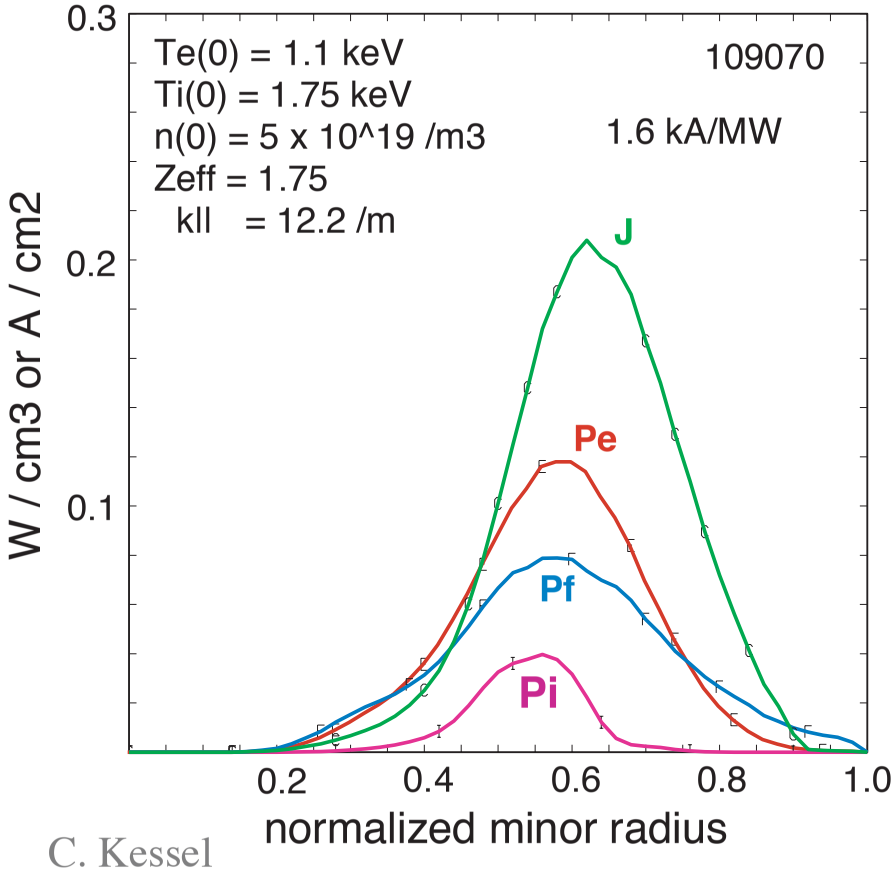
Provides a Tool Modify Profile

HHFW in Low β Plasma



A. Rosenberg

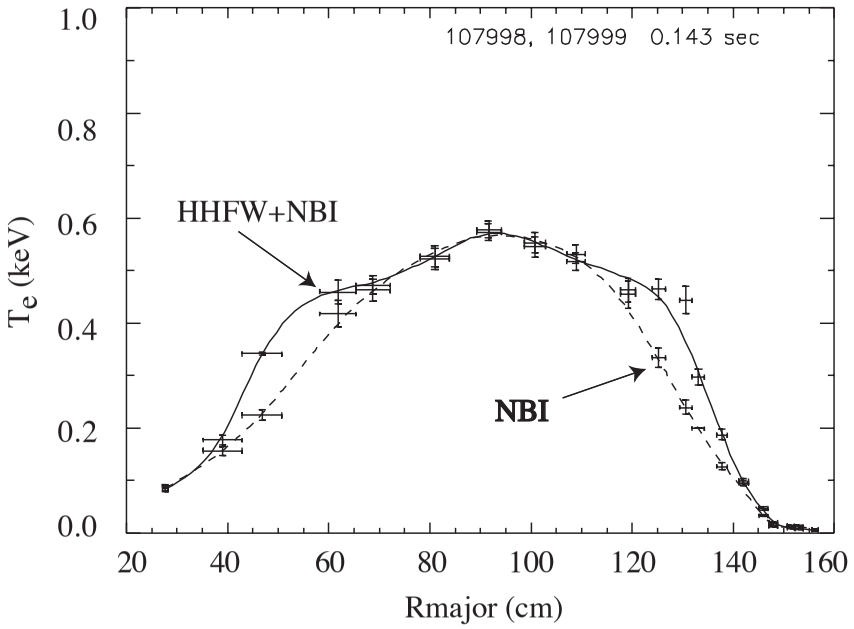
HHFW in High β Plasma

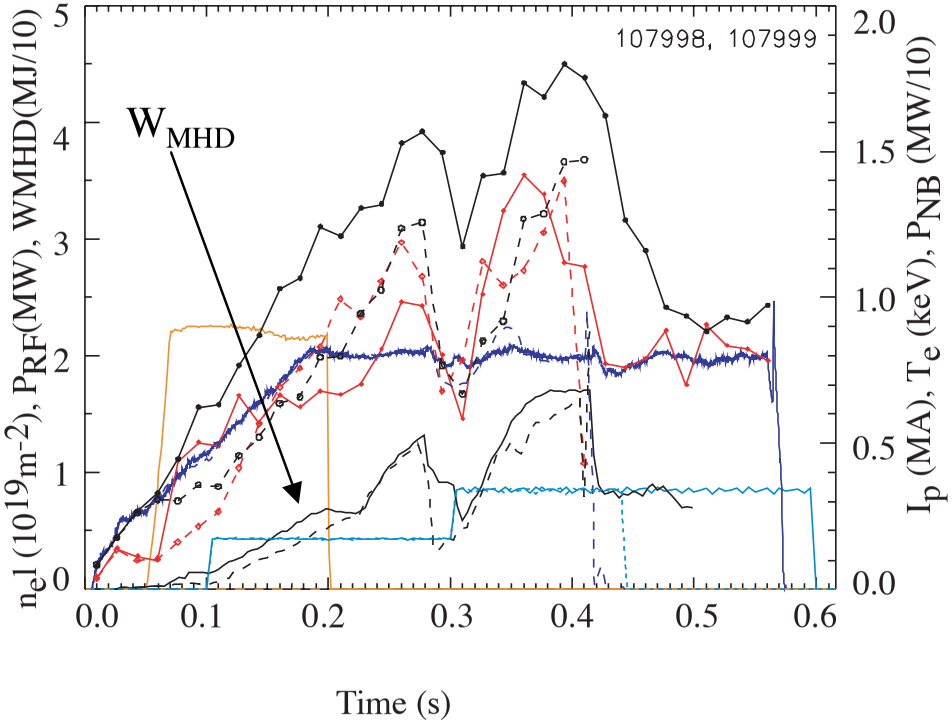


C. Kessel

CSL: HHFW+NBI vs NBI

Observe W_{MHD} increase when HHFW+NBI during Ip ramp



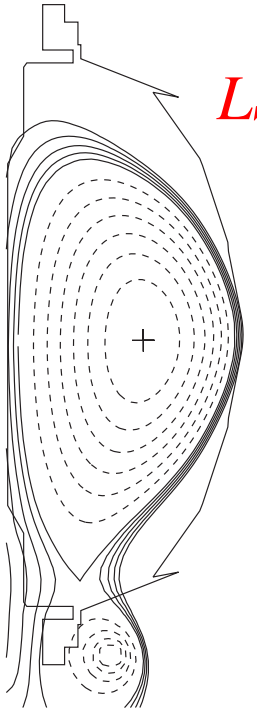


We Already Have Some Interesting HHFW + NBI Plasmas (LSN)

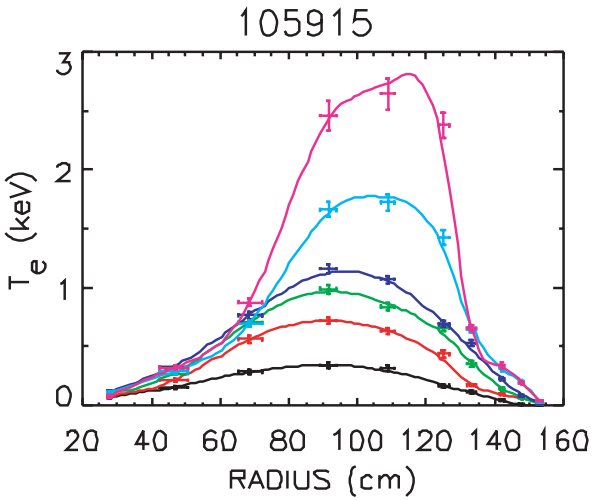
$I_p \leq 1$ MA

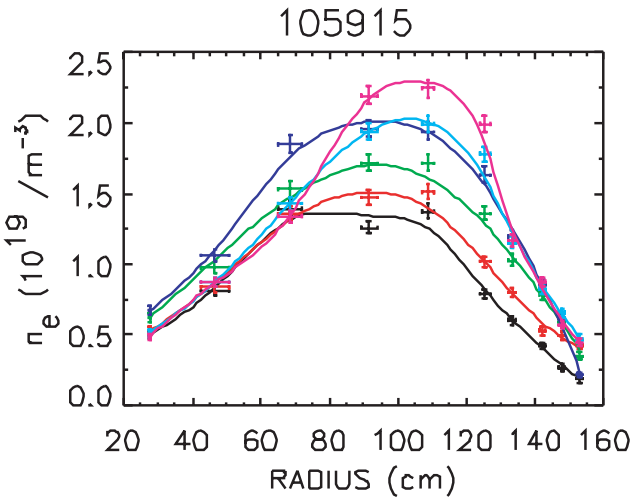
$B_T = 0.45$ T

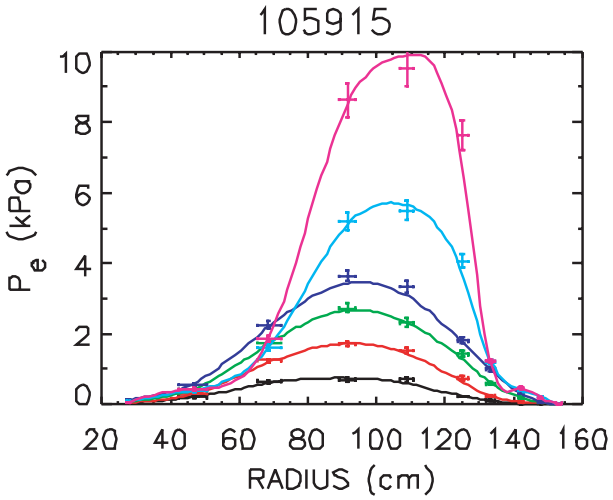
Te ≤ 2.7 keV

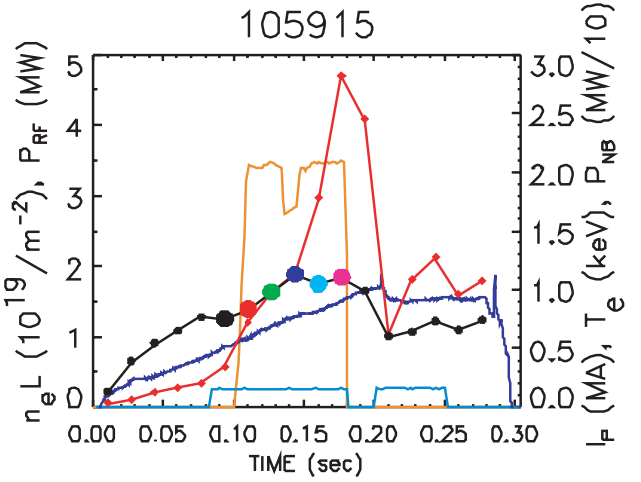


LSN







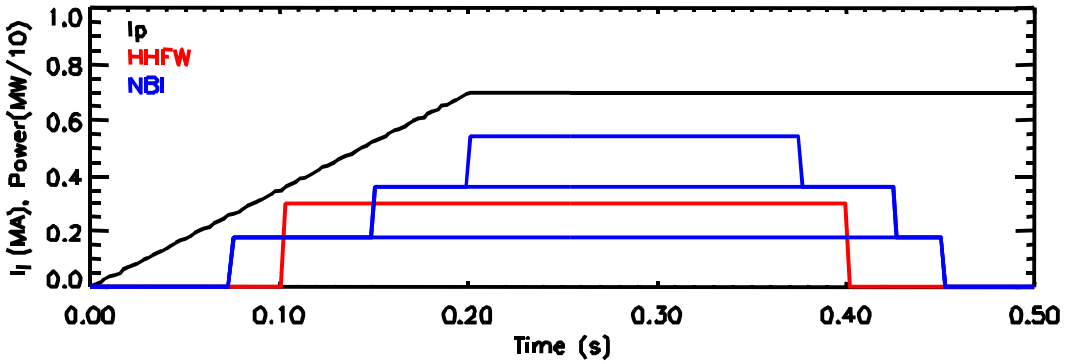


Experimental Plan: Re-establish 105915

- Re-establish 105915, LSN, 0.8 MA, 0.45 T (109757)
  - May need to start with k// = 14 m^{-1}
  - Optimize with k// = 7 m^{-1}
    - Run three cases: co-, iso-, counter phasing and investigate
      - Loading versus phasing
      - Electron and ion heating versus phasing
      - Energetic ion production
      - MHD activity
- Identify best case based on high core T_e and W_{mhd}.
  - Obtained no-HHFW reference discharge

Part 1: 0.7 MA, 0.45 T dIp/dt stops at 0.2 s

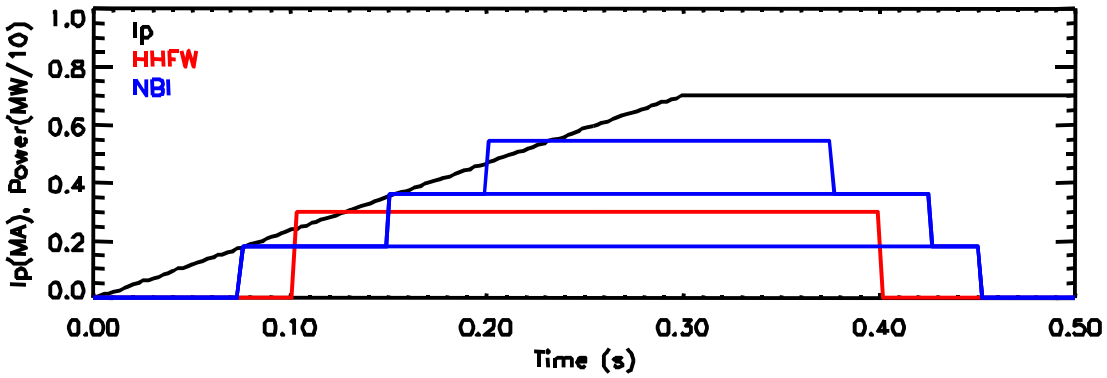
- $P_{HHFW} \geq 3$ MW, $k_{//} = 7$ m-1, or 14 m^{-1}
- Do a NBI power scan: 0, 1, 2, 3 beams
  - Select best case, most likely 2 beams
  - *Get no-RF shot*
  - Repeat with co- and counter phasing ($k_{//} = 7$ m^{-1}).
- Do B_T scan (0.45), 0.4, 0.35 T based on above best case
  - *Get no-RF shots for each B_T.*
- Set $k_{//}$ = 14 m-1
  - Repeat best case for 0.45 T, 0.4 T and 0.35 T at $k_{//} = 14$ m^{-1}.



Part 2: 0.7 MA, 0.45 T dIp/dt stops at 0.3 s

Does Ip ramp matter?

- $P_{HHFW} \geq 3$ MW, $k_{//} = 7$ m-1
- Do a NBI power scan: 0, 1, 2, 3 beams
  - Select best case, most likely 2 beams
  - *Get no-RF shot*
- Do B_T scan (0.45), 0.4, 0.35 T based above on best case
  - *Get no-RF shots for each B_T.*



Ascertain Current Drive

This part of experiment would no be attempted on day one

- Might be difficult to do under NBI conditions
  - Or easy is HHFW has small effects on kinetic profiles
- Compare co-counter CD for optimum conditions
  - Select best co condition, flat Ip would be preferable…
  - Match electron parameters with counter heating conditions and establish co-counter comparison
- Need MSE or X-ray tangential camera

Experimental Plan: New tools...

- Match plasma shape to antenna shape
  - Should we try DND?
- Control density
  - Use center stack gas puff to separate coupling from fueling
- Pay attention to edge effects
  - Edge rotation (and temperature) diagnostic
    - *Observed edge anomalous ion heating during RF, which was unexpected*
  - RF probe, just installed
  - Fluctuation measurements

Concluding Remarks

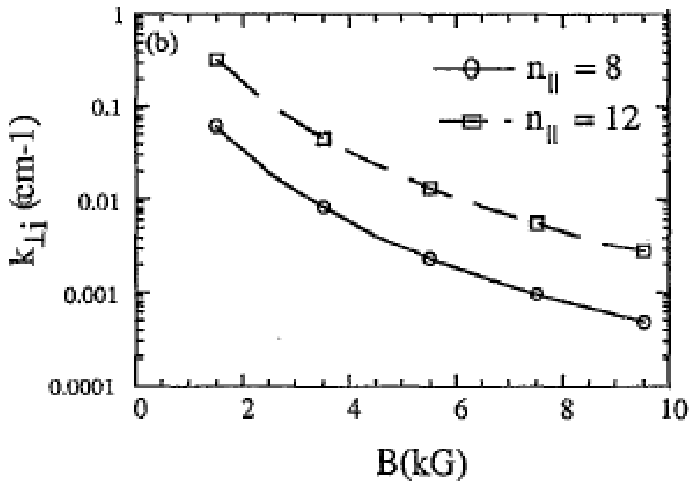
- This is will a challenging experiment
  - But interesting payoffs
    - HHFW+NBI plasmas for NSTX
    - CD in HHFW+NBI
    - HHFW in high Beta plasmas
    - May uncover RF driven transport effects

END OF TALK

Theoretical Expectations for Electron Power Absorption by HHFW

- Electron power absorption of HHFW wave
  - Increases with β_T
  - Increases with $k_{//}$.
- Can we verify that?

Electron power absorption in a LART device.



Imaginary part of $k_\perp$ against magnetic field, for two values of $n_{//}$.

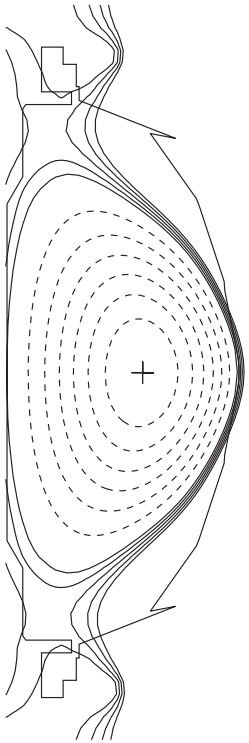
M. Ono, Phys. Plasmas 2 (1995) 4075

We Already Have Some Interesting HHFW + NBI Plasmas (CSL)

$I_p \leq 0.9$ MA

$B_T = 0.4$T

Te ≤ 1.6 keV



CSL